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Indoor Air Ion Concentration Variability Assessment

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ABSTRACT

This study focused on indoor air ion variability assessment of some Residential buildings (Rb) in Port Harcourt City. Ten Residential buildings (Rb) in different parts of Port Harcourt City were selected for the study. The geographical coordinates of each of the Residential buildings were determined using a geographical positioning system. A calibrated air ion meter was positioned 1.5 meters above the floor of each of the selected buildings. The indoor air ion concentration levels of the selected buildings were measured daily for a period of two weeks. The positive air ion levels for the period under study range between 100 ions/cm^3 and 2900 ions/cm^3, while the negative ion levels range between 100 ions/cm^3 and 4000 ions/cm^3. Six out of the ten Residential buildings namely Rb2, Rb3, Rb5, Rb8, Rb9, and Rb10 had higher positive ion concentration levels than negative ion while the remaining four Residential buildings namely Rb1, Rb4, Rb6, and Rb7 had higher negative ion concentration levels than positive ion. The difference in ion concentration levels of the six Residential buildings -- Rb2, Rb3, Rb5, Rb8, Rb9, and Rb10 can be attributed to the fact that negative ions have higher mobility values than positive ions. Again, this difference can also be attributed to high levels of air pollution in the six buildings, as polluted air is mostly dominated by positive ions. Of all the ten buildings assessed for air ions, only Rb1 and Rb5 had negative air ion concentration values of 1400 ions/cm^3 and 4000 ions/cm^3 falling within what the World Health Organization regarded as fresh and clean air for oxygen ion concentration.

Keywords: Indoor air ions; Concentration; Variability; Assessment.

1. Introduction

Air ions are charged particles that exist in the air, and their presence can affect the air quality and the health of human beings. The term “air ion” in atmospheric electricity refers to all charged particles in the air that serve as electric current (Hõrrak et al., 2003). Herczeg and Erces (2015) estimated that somewhere about 60% of the air we breathe contains ions. Negative air ion (NAI) plays a critical role in the promotion of physiological functions of the human body and is a significant indicator of how clean the air is, in an area (Guangyao et al., 2021). Harrison & Aplin (2007) also reported that high levels of air ions could be indicative of lower particle concentration in the atmosphere. There is always the presence of small ions in the atmosphere, and the estimated average concentration of the small ions is between the range of 200 – 2500 ions/cm^3, and sometimes, concentration could get up to 5000 ions/cm^3 (Hirsikko et al, 2011). Cluster ion concentration between 400 ions/m^3 and 3000 ions/m^3 is commonly regarded as appropriate for the well-being of humans (Skromulis, 2019). Ions produced by cosmic rays have been thought to influence aerosols and clouds (Svensmark et al., 2017). These ions could be tiny or molecular ions, and the large ions (Langevin ions). Most of the air ion production is said to emanate from ionizing radiation (Chen et al., 2016). According to Hirsikko et al. (2021) atmospheric ions also called air ions, are responsible for atmospheric electricity. These ions are responsible for atmospheric conductivity. Richmann in 1744 discovered the electrical conductivity of air and was also rediscovered by Coulomb (1785) (Hirsikko et al., 2021). Eighty percent (80%) of ionizing radiation near the Earth’s surface comes from the soil and air and as such, any alteration in radioactive elements will impact the ionization of the atmosphere, as well as atmospheric conductivity, which in turn introduce changes in the atmospheric electric field (Li et al., 2022). Atmospheric conductivity has been identified to be dependent on ion mobility and ion concentration, but ion concentration is influenced by the number of ions produced and loss processes (Baumgaertner et al., 2023). Rycrofta et al. (2000) posited that in a fair-weather

condition, the atmospheric conductivity "near the surface is on the order of 10^{-14} $ohm^{-1}m^{-1}$ and increases with height up to 60km, with a scale height of about 7 km". Below 60 km, the dominant charge carriers are small ions of opposite signs—positive and negative from galactic cosmic rays, but beyond 60 km, free electrons become the major charge carriers and their exponential increase in conductivity throughout the mesosphere is due to their large mobility, while above 80 km, the geomagnetic field makes conductivity within this region anisotropic (Rycrofta et al., 2000).

The number of atmospheric ions depends on several factors such as time of day, weather, and location, as do the number of people in the area and their level of activity (Herczeg & Erces, 2015). Wallner et al. (2015) reported that waterfalls' environment can generate air ion concentrations as high as 10^5 ions/cm^3 while in big cities and indoor environments, the ion concentrations drop drastically. Meteorological parameters such as temperature, humidity, and wind affect the concentration of air ions (Pawar, 2011). The concentration of positive and negative ions is also affected by rainfall and wind speed (Pawar, 2014). The result of the experimental study by Wang and Li (2009) has shown that as the light intensity and duration of illumination change, the NAI concentration of plants also change. Positive ions are always present in the environment, but they become more concentrated, especially when there is low humidity and moderate to high temperatures (Hetzler 2017, February 26). Li et al. (2015) also observed a positive correlation between small ion concentration and temperature as well as relative humidity. This was also corroborated by Xiao et al. (2023) that "negative air ion concentrations vary temporally with solar radiation, air temperature, and relative humidity".

1.1. Ion Mobility

Variations in ion velocity also reveal subtle dimensions. In ambient air, ions with smaller sizes travel at 1–2 cm/s while those with larger sizes travel at 0.01-0.005 cm/s. Studies have shown that negatively charged ions travel faster than positively charged ions (Herczeg & Erces, 2015). The results of an experimental study by Liu et al. (2015) showed that ion mobility decreases non-linearly with an increase in humidity. Wright et al. (2014) study revealed a higher mobility of ions in the downwind direction compared with the upwind direction for both ion polarities, but the increase was not statistically pronounced.

1.2. Effect of Air Ions

In 1931, Dessauer published the first multidisciplinary analysis of the effects of ionized air on health. Participants were assessed by having ionized air blown in a funnel over their faces. At a concentration of 10^6 ions/cm^3, exposure times ranged from 15 to 60 minutes. It was demonstrated, both among healthy volunteers and inpatients, that positive and negative ions affected human health differently. Positive ions caused irritation, head pain, elevated blood pressure, and increased breathing rate. On the other hand, the effects of negative ions were revitalizing and lowering blood pressure (Herczeg & Erces, 2015). Negative air ions can lessen nasal and skin irritations or dryness, drowsiness, and increased heart rate due to exposure to pure CO_2, as well as a positive effect on cognitive performance when one is exposed to them for an hour (Guo et al., 2023). Studies have shown that "exposure to negative air ions may benefit our health by changing amino acid metabolism, which mainly manifests as increased anti-inflammation and reduced inflammation and anti-oxidation" (Xiao et al., 2023). More so, negative air ions

enhance biochemical reactions that elevate mood chemicals called serotonin, which is responsible for alleviation of depression and relieving of stress (Nazario & Maan, 2002 May 6). According to Cheng et al. (2022), "NAIs have been found to inhibit the growth of bacteria and fungi on solid media, to exert a lethal effect on vegetative forms of bacteria suspended in water, and to decrease the viable count of bacterial aerosols". High level of positive air ions (PAI) can induce severe inflammation and allergies, depression, chronic pain, and mood swings (IonLoop, 2017 November 10).

1.3. Environments for Positive Air Ions

Positive air ions (PAI) are dominant during fair weather conditions, and the two possible causes of this scenario are: small negative ions have higher mobility resulting in their accelerated grounding and also, the potential difference between the earth's surface and the ionosphere initiates the flow of positive air ions to the earth (Lorenz, 1961). IonLoop (2017, November 10) stated that anything that possesses electromagnetic capabilities, such as televisions, phones, computers, fluorescent lighting, etc., will give out harmful positive ions. Polluted air is mostly dominated by positive ions. According to Ogungbe (2011) "the most dangerous levels of harmful positive ions occur in the polluted, large industrial and heavily populated cities".

1.4. Environments for Negative Air Ions (NAI)

Vegetation favours negative ion production. Studies have shown that forests generate negative air ions, thus making them part of the natural sources of NAI (Jiang et al., 2018). These negative air ions are commonly produced by leaf tips (Wang & Li 2009). Negative ions (NAIs) are mostly in high concentration in an environment where there are waterfalls and flowing waters, as these produce oxygen ions (https://elanra.com/negative-ions/). NAIs are also generated in large amounts after thunderstorms and lightning (Jiang et al., 2018).

2. Materials and Method

Materials employed in this study include a Global Positioning System (GPS), air ion meter, and measuring tape.

2.1. Method

Ten Residential buildings (Rb) in different parts of Port Harcourt City were selected for the study. The geographical coordinates of each of the Residential buildings were determined using a geographical positioning system. The air ion meter was calibrated to ensure accurate measurements of the indoor air ions and positioned 1.5 meters above the floor of each of the selected buildings. The indoor air ion concentration levels of the selected buildings were measured daily for a period of two weeks. The average positive and negative air ion concentration levels of the selected buildings were calculated.

3. Results and Discussion

Table 1 shows the locations of the sampled Residential buildings (Rb) and their geographical coordinates.

Table 1. Locations of the Sampled Residential Buildings and their Geographical Coordinates

House ID	Location	Latitude	Longitude
Rb1	Choba	N4^{0}45′11.15″.	E7^{0}0′35.24″
Rb2	Rumuokwuta	N4^{0}52′19.10″	E7^{0}6′37.09″

Rb3	Trans-Amadi	N4^{0}52′18.00″	E7^{0}4′37.00″
Rb4	Rumukrushi	N4^{0}48′44.24″	E7^{0}4′35.00″
Rb5	Mile II Diobu	N4^{0}51′26.84″	6^{0}55′34.36″
Rb6	Elelenwo	N4^{0}49′44.25″	E7^{0}3′31.56″
Rb7	Rumuagholu	N4^{0}53′10.48″	E7^{0}2′31.28″
Rb8	Ikoku, Mile III	N4^{0}54′12.50″	E7^{0}2′19.15″
Rb9	Rumuolumeni	N4^{0}52′17″	7^{0}6′33.00″
Rb10	Marine Base	N4^{0}45′11.15″	E7^{0}0′35.24″

The calculated indoor air ions mean concentration levels in the selected buildings-- Rb1, Rb2, Rb3, Rb4, Rb5, Rb6, Rb7, Rb8, Rb9, and Rb10 for the period under study are shown in Figure 1.

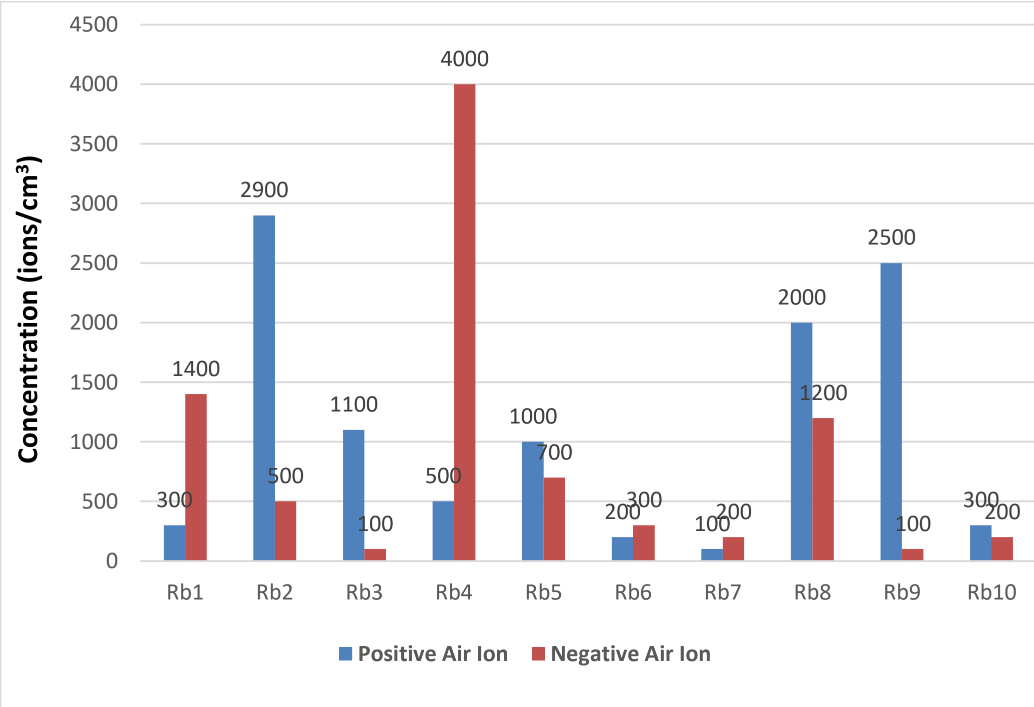

Figure 1. Positive and Negative Air Ions Concentration Levels of the Selected Residential Buildings

The positive air ion levels for the period under study range between 100 ions/cm^3 and 2900 ions/cm^3, while the negative ion levels range between 100 ions/cm^3 and 4000 ions/cm^3.

In Figure 1, six out of the ten Residential buildings namely Rb2, Rb3, Rb5, Rb8, Rb9, and Rb10 have higher positive ion concentration levels than negative ion while the remaining four residential buildings namely Rb1, Rb4, Rb6, and Rb7 have higher negative ion concentration levels than positive ion. The difference in ion concentration levels of the selected Residential buildings can be attributed to the fact that negative ions have higher mobility values than positive ions. Negative ions are statically attracted to airborne particles such as dust in the environment (Holistic Lakewood LLC, 2019 September 16). The results of the levels of positive and negative ions in this study are consistent with the present ratio between positive and negative ions. Studies have shown that the proportion of

positive and negative air ions presently is 1.2: 1, which is different from what it used to be 1: 1.2 in the early 20th century (Gao et al., 2016). This means that those buildings with higher positive air ions have less fresh and clean air than those with higher negative ions. According to World Health Organization (WHO), when an environment has oxygen ions concentration in the air that is not below 1000-1500 ions /cm^3, the air is regarded as fresh and clean by (Gao et al, 2016).

4. Conclusion

In conclusion, the indoor air ion concentration variability assessment of the selected buildings revealed that only two out of the ten Residential buildings selected for the study had negative air ion concentration falling within what the World Health Organization regarded as fresh and clean air.

Declarations

Source of Funding

This study did not receive any grant from funding agencies in the public or not-for-profit sectors.

Competing Interests Statement

The authors have declared no competing interests.

Consent for Publication

The authors declare that they consented to the publication of this study.

Availability of Data and Materials

No associated data is available in the manuscript.

Author's Contribution

Both the authors took part in data collection, literature review, analysis, and manuscript writing equally.

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